Milroy (W. F.)

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WATER SUPPLY IN OMAHA

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Professor of Histology, Pathology and Hygiene, Omaha Medical College.

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When the report of the Board of Health of Omaha for the last six months of 1887 appeared, I was greatly astonished at the number of deaths that had occurred from typhoid fever during that time.

A man of such world-wide reputation as Dr. Edmund A. Parkes, F.R.S., of London, has said of typhoid fever that it is a disease "altogether and easily preventable." I believe this statement to be the truth, and therefore that ninety deaths should have occurred from this disease, in a city the size of Omaha, in one brief half year, is positive evidence that something is fatally wrong. I believe that of those ninety persons whose bodies are now rotting in the ground all, or nearly all, might to-day have been living and occupying their allotted place in the family and community if only the knowledge had been acted upon, which that noblest of sciences, Hygiene, has placed within the reach of every community.

Deeply impressed with the importance of these truths I imposed upon myself the task of discovering, if possible, wherein lay the evil and on whom rested the responsibility of this useless slaughter.

Speaking with scientific exactness, it is impossible in most diseases to assign a cause with absolute certainty to any specific case, but I stand here to-night to demonstrate to all within the sound of my voice, to within the smallest degree of a certainty, that the sickness and deaths in Omaha from typhoid fever in 1887 were wholly unnecessary, because it was within the power of that community to prevent them.

The detective who is detailed to the duty of tracing out a mysterious murder case first makes a deliberate and careful study of all the facts that are known concerning the matter in hand, endeavoring to assign to each its due importance, weighing each circumstance in the light of all the others and even considering the theories advanced by those more or less interested in the crime that has been committed. From all these facts and figures duly digested he takes his clue, and, this done, proceeds upon the more active pursuit of the criminal. Likewise, we, in seeking to establish the identity of the cause of the fatal outbreak in question, must first get clearly in mind all the established facts and well substantiated theories relative to the causation of typhoid fever, and then in the light of these we may proceed to apply them to the circumstances as we find them in the city of Omaha.

The time at my disposal forbids all discussion of problems that still remain unsettled concerning this disease. I shall therefore limit my remarks to such facts as all acknowledge.

Typhoid fever is found in all countries. It is favored by the conditions of civilization, though these are not essential to its existence. The predisposition to it is greater before thirty years of age, though it may occur late in life. New-comers in an infected locality are much more liable to the disease than old residents. In other words, habitual exposure to the causes of it render a degree of protection against their effects. Occupation or station in life have no influence in themselves. Its occurrence is more frequent in the late summer and early autumn. Most authors agree that typhoid fever is unusually prevalent after summers remarkable for their dryness and high temperature, but the amount of precipitation is of much more importance than the temperature.

"The exciting cause of typhoid or enteric fever (in the words of †Dr. Edwin R. Maxon)

*Read before the Medical Society of the Missouri Valley, March 21st, 1889, at Council Bluffs, Iowa.

†N. Y. Medical Journal, August 15, 1885.

doubtless consists of a poison generally derived from a pre-existing case, probably the *typhoid bacillus*, which has been found in the lymphatics, blood and tissues; but sometimes arising, as all contagious diseases did originally, from an equivalent poison, 'generated anew by the decomposition of sewage and of other forms of animal filth.' In either case the typhoid poison is reproduced in the system during the fever, and it appears that its chief, if not exclusive outlet, is in the intestinal discharges."

Such being the origin of the disease, it is evident that if this danger can be guarded against the disease will cease to exist. Thus the whole matter for the consideration of the Sanitarian, with respect to typhoid fever, is reduced practically to two questions: First, by what means do the stools of typhoid fever patients, or an equivalent poison, find access to the bodies of healthy individuals; and, secondly, by what means can the access of this poison be cut off.

A statement in full of the answer, which I believe to be the correct one, to the first of these questions, together with the evidence which may be offered in support thereof, would occupy many hours. I will therefore answer it by quoting from a number of authors, among whom are those who have done more than all the world besides to solve these difficult questions, and whose opinions must be accepted as final.

At the Congress of Hygiene, September, 1887, M. Brouardel opened the discussion on the mode of propagation of typhoid. "*Brouardel was sustained in his opinion that the vehicles for the transmission of typhoid fever germs were water, air, and clothing in contact with the sick; that the great source of the transmission of the disease was the pollution of drinking water."

†Dr. Edwin R. Maxson, LL.D., of Syracuse, N. Y., states: "The most common vehicle of the poison appears to be drinking water contaminated through sewage, either when drank alone or with milk, with which it has been mixed."

*Dr. Frank P. Foster, editor of the *New York Medical Journal*, remarks: "The water used for drinking is so commonly recognized as the chief vehicle of the germ of typhoid fever that even isolated instances in which it is evidently not at fault are of interest."

The eminent sanitarian, †Mr. Jas. C. Bayliss, states: "In country districts the germs of typhoid fever are most frequently communicated to the human system through drinking water drawn from wells and springs contaminated with impurities. This also occurs to a great extent in cities and small towns not provided with water works, and in which the inhabitants are dependent on wells necessarily sunk in close proximity to privy vaults, and cess-pools for the reception of house drainage."

‡The English Rivers Pollution Commissioners in their sixth annual report, remark: "The investigation of the epidemic of typhoid fever at Lauzen proves that very efficient filtration does not prevent the propagation of typhoid fever by water. Nothing short of abandonment of the inexpressibly nasty habit of mixing human excrement with our drinking water can confer upon us immunity from the propagation of epidemics through the medium of potable water."

§Dr. Henry B. Baker, Secretary of the Michigan State Board of Health, after speaking of other causes of typhoid fever, says: "That disease is not frequently traced to transmission through the air, but is frequently traced to the use of bad water."

‖Prof. V. C. Vaughan, Director of the Michigan State Laboratory of Hygiene, in concluding a report upon an investigation of suspected water, remarks: "There are on an average about one thousand deaths and ten thousand cases of sickness from this disease (typhoid fever) annually in Michigan. These figures can be greatly reduced if people will cease polluting the soil about their houses with slops, garbage, cess-pools and privy

*Sajous' Annual of the Universal Medical Sciences, 1888, vol. v, p. 252.

†Loco Cit.

*New York Medical Journal Oct. 22, 1887.

†House Drainage and Water Service.

‡Treatment and Utilization of Sewage, Corfield, p. 295.

§Typhoid Fever and Low Water in Wells: Reprint from Annual Report for 1884 of the State Board of Health of Mich.

‖First Quarterly Report of the Mich. State Laboratory of Hygiene, 1888.

vaults, and will see to it that their drinking water is pure beyond all question."

A *circular published by the State Board of Health of Illinois contains the following statement: "Where there is a polluted water supply, where there is undrained ground, contaminated with excremental filth, where foul overflowing or leaky privy vaults soak the earth for rods with their contents, where defective, unventilated sewers and 'skin' plumbing abound, there does typhoid fever find its most numerous victims. From such localities the contagion, finding its way by various unsuspected channels, may invade the most cleanly and carefully ordered household. The frequent mode by which it is spread is through the water supply. A small quantity of the infectious matter of the disease is sufficient to poison the contents of a well or cistern and thus to give rise to an outbreak among the susceptible who depend upon such source of supply. Or this may, as has frequently been proven, be used for dairy purposes, and so introduce the infection into families supplied with milk from such dairy miles away from the source of danger."

In a †document issued by the Michigan State Board of Health in June of last year, concerning the prevention of typhoid fever, is the following: "Water chemically pure does not necessarily cause the disease, but drinking water contaminated with the fecal discharges of a typhoid fever patient is believed to be the most common source or vehicle of typhoid fever. While the possibility of its originating in other ways is not denied, the frequent outbreaks of this disease which are traceable directly and unmistakably to a contaminated water supply, seem to point to this as the chief source of danger. The disease has also been traced to milk diluted with infected pump water and apparently to emanations from sewers and cess-pools."

As long ago as 1879 the statement is made in the Annual Report of the State Board of Health of Massachusetts, that, "So far as Massachusetts is concerned impure water is one of the most common sources of infection from typhoid fever."

*Ill. State Board of Health Preventable Disease Circulars, No. 4.
†Prevention of Typhoid Fever.

Dr. George Wilson, Fellow of the Sanitary Institute of Great Britain, etc., *says, in speaking of typhoid fever: "Although there are still some who do not believe in the communicability of the disease, there is a constantly accumulating amount of evidence which goes to prove not only that the poison of the fever may be conveyed through the agency of water from the sick to the healthy, but that this is the most common mode of propagation. Sir W. Jenner (he further states), than whom no higher authority could well be quoted, in commenting upon this point, says: 'The spread of typhoid fever is if possible less disputable than the spread of cholera by the same means. Solitary cases, outbreaks confined to single houses, to small villages and to parts of large towns—cases isolated, it seems, from all sources of fallacy—and epidemics affecting the inhabitants of large, though limited localities, have all united to support by their testimony the truth of the opinion that the admixture of a trace of fecal matter, but especially the bowel excreta of typhoid fever, with the water supplied for drinking purposes, is the most efficient cause of the spread of the disease, and that the diffusion of the disease in any given locality is limited or otherwise, and just in proportion as the dwellers of that locality derive their supply of drinking water from polluted sources.'"

In the †report in November, 1888, of the committee on the pollution of water supplies, appointed by the American Public Health Association, is the following statement: "In the records of Sanitary Science are to be found many epidemics of typhoid fever chargeable to wells that have become contaminated by sewage. Indeed, the more the transmission of typhoid fever is studied, the more evident is it that the water supply is the main agency concerned in its propagation. Hence sanitary officers have not only closed up wells into which sewage has entered, but those which from their situation are merely exposed to this danger."

I might go on almost indefinitely with this line of evidence, but enough has been said,

*Handbook of Hygiene, fifth edition, p. 208.
†Reprint for the Michigan State Board of Health, p. 13.

and the answer to my first question, By what means do the stools of typhoid fever patients or an equivalent poison find access to the bodies of healthy individuals? must be apparent to all. Barring exceptional cases, it is by means of polluted drinking water. So that we must conclude that there is in use by a large number of the citizens of Omaha a polluted drinking water, and that if this practice could be stopped we would have no more deaths from typhoid fever to record. Can we discover the source of this death-dealing fluid? We shall see.

With the facts in mind to which I have thus far called attention, it was at once apparent that my task of locating the evil sought and the responsibility therefor, lay in the direction of a study of the water supply of Omaha and its relation to the sickness and deaths in question. To this end I procured from the records of the Board of Health a list of the names of all the persons who had died from typhoid fever during the last six months of the year 1887, ninety-six in number, together with the address at which the death had occurred, and such other data as the records furnish. This done, I set about the laborious task of making a personal inspection of the premises where each death had taken place. I made note of the source of water supply and the possible sources of contamination of the same, and also the general condition of the premises with respect to sanitation.

At the outset I was met by a very serious obstacle in the inaccuracy of the addresses given. Many were indefinite, many absolutely wrong, and a few were not given at all. Moreover, the fact that a year had elapsed since the sickness occurred rendered the difficulty in tracing the cases greater. And just here I desire to respectfully urge upon our Board of Health the necessity of adopting measures to secure a full and accurate report of all deaths occurring in the city. The chief merit or demerit of any statistics lies in the degree of their accuracy.

The following are the results of my investigation: The whole number of deaths which occurred during the six months was ninety-six. In my opinion, and I suppose that of most of those whom I address, the typhoid poison is just as truly a causative agent in the production of those cases called "typho-malaria" as in those called simply typhoid. Though, to avoid any ground for dispute, I have omitted these, were they included it would bring the entire number of deaths up to one hundred and ten. Of the ninety-six, fifty-four were males and forty-two females. The average age was twenty-three and one-half years, about. There were thirty-four native to the United States, and fifty-nine foreigners, and three not specified. The deaths occurred, in July, thirteen; August, twenty-eight; September, twenty-two; October, twenty-one; November, seven; and December, five. Of the ninety-six cases, thirty-five died in St. Joseph and the Child's hospitals. As neither of these institutions preserves a record of the former residence of their patients it was impossible to trace them. Of the remaining sixty-one cases the address in seven was so incorrectly given that I found it impossible to find a clue to them, though neither time nor labor was spared in an effort to do so. There were, therefore, only fifty-four remaining of the whole ninety-six whose former residence I was able to examine. It will be observed from the above statement that there was no opportunity for the exercise of a prejudice in the selection of cases.

In forty-seven cases, in which the sanitary condition exclusive of water supply was noted, it is marked bad in one, fair in five, and good in forty-one. Of the fifty-four cases the water supply in three was from cisterns, in four from the public supply, and in forty-seven from wells. The alleged quality of the well water is noted in forty-five cases. It was in thirty-eight good, and in seven suspicious or bad. Aside from the fatal cases, I have learned of seventy-nine other cases of typhoid fever among those using the water from twenty-two of these wells. In the case of eleven of the wells, a history is given of sickness among those using the water; from diphtheria, a large number of cases, quite a number of which were fatal; from malaria and typho-malaria, a great number of cases; and from bowel troubles and other more or less ill-defined symptoms, very many cases.

Of the cisterns referred to, one had no cover, and at the time of inspection contained but little water, with sticks and other rubbish floating in it, probably thrown there by a number of neglected children who were playing about. The other two appeared to be fairly well cared for, but it is worthy of note that in each of these families there was another case of typhoid fever at the same time. They were all cement cisterns, which are very liable to contain cracks through which soakage from without may pass and mix with the contents of the cistern. Of the cases where city water was used, No. 1 was a girl of seventeen, who slept in a room through which passed the soil pipe from the closet above, and this was defective, as was shown by an offensive odor whenever the house was not ventilated. Her brother had a mild attack of the disease afterward. No. 2 was a woman of thirty-five, who occupied a flat above a store. At the rear of this all the garbage, waste water and human excrement of the families in the row was thrown, thus creating such a stench that at least one tenant on the lower floor moved out on account of it. From the information gained I am unable to offer any explanation of the mode of infection in the other two cases. I am aware that there are many who will pooh-pooh the idea that in the remaining cases the wells have been the cause of the sickness and deaths. I am aware, also, that I am unable to offer an absolute demonstration that this is true; but is not this alone a significant fact, in view of the testimony which I have presented respecting the usual mode of transmission of the disease, that of the fifty-four cases examined the *city water was used in only four?*

Space will not permit me to relate specifically each of the fifty cases in which the city water was not in use, but of many in which the clinical evidence was very convincing I will mention as an example the following: A dressmaker on the premises employed eight women. Her own family consisted of three persons—eleven all told. From the surroundings of the well she judged the water to be unfit for use, and used, for drinking and cooking, melted ice which she bought for that purpose. Six of the employees also drank the ice water, but two of them, believing the well water to be better, drank this. Both of these were taken sick and died from typhoid fever. None of the others took the disease. Among those using this well there were at least thirteen other cases of typhoid fever.

It might be mentioned in this connection, that the proprietor of the dressmaking house asked of the landlord the privilege of putting in, at her own expense, the city water, which was in the street upon which the property fronts. This he refused on the ground that the other tenants, depending upon the well, would also demand city water and this would cost too much money.

It is well known that it is for the most part among the less wealthy people of our city that wells are in use. I fancy that some one may seek to shield the wells by attributing this peculiar distribution of the fatality from typhoid fever to inferior attendance and nursing which the sick among poor people are likely to receive. I will answer this objection only by the following quotation* from the exhaustive article of Dr. James H. Hutchinson, of Philadelphia: "The rich are not only as liable to contract typhoid fever as the poor, but the disease is also quite as fatal among them. Murchison found from the statistics of the London Fever Hospital that the mortality is not greater among the destitute than among the better class of patients, and expresses the opinion that in private practice enteric (typhoid) fever is probably more fatal among the upper classes than among the very poor. Chomel and Forget seem to have reached a similar conclusion."

Being desirous to test Omaha's water supply by actual analysis, and that by a chemist of such acknowledged ability and reputation that his conclusions could not be gainsayed, I corresponded with Prof. Victor C. Vaughan, director of the Michigan State Laboratory of Hygiene, at Ann Arbor. Through his interest in the subject in hand I am enabled to present a report of ten analyses by him. The samples were collected by myself, care being exercised to get a fair specimen of each. From each

*Pepper's System of Medicine, Vol. I, p. 320.

source of supply a new one-half gallon glass demijohn was filled, stoppered by a new cork and hermetically sealed. These were labeled by number.

They were taken from the vicinity of the following places: Nos. 1 and 2, Cuming and 20th st.; No. 3, Vinton and 11th st.; No. 4, Martha and 13th st.; No. 5, Grace and 22nd st.; No. 6, Charles and 18th st.; No. 7, Marcy and 7th st.; No. 8, Dodge and 17th st.; No. 9, Davenport and 10th st., and No. 10 from the hydrant of the City Water Co., in my own house, without filtration.

Prof, Vaughan writes as follows:

REPORT ON ANALYSES OF WATERS SENT FROM OMAHA BY PROF. W. F. MILROY, M. D.

I. CHEMICAL ANALYSIS.—In all the waters the free ammonia, albuminoid ammonia, chlorine, nitrites, nitrates and hardness were determined with the following results:

No.	Free Ammonia.		Albuminoid Am'nia		Chlorine.		Nitrites.	Nitrates.	Hardness.
	Parts Per Million.	Grains Per Gallon.	Parts Per Million.	Grains Per Gallon.	Parts Per Million.	Grains Per Gallon.			Clark's scale
1	.168	.0098	.118	.0069	129	7.523	None.	Good test.	33
2	.08	.0047	.124	.0072	97	5.656	"	"	33
3	.664	.0387	.230	.0134	12	6.998	"	None.	31
4	.162	.0098	.116	.0068	45	2.624	"	Good test.	38
5	.094	.0055	112	.0065	23	1.341	"	Slight trace.	29
6	.028	.0016	.090	.0053	34	1.982	"	Good test.	28
7	.022	.0013	.102	.00595	48	2.799	"	Trace.	33
8	.172	.0100	.088	.0051	48	2.799	"	Good test.	33
9	.054	.0032	.068	.00397	98	5.715	"	"	34
10	.032	.0019	.096	.0056	8	.4665	Distinct trace.	Trace.	18

No absolute standard for the chemical purity of water can be given, but good authorities agree upon the following rules:

(1.) The chlorine ought not to exceed ten parts per million.

(2.) The free ammonia ought not to be more than .05 part per million.

(3.) If .10 part of albuminoid ammonia is present the water should be regarded as suspicious.

(4.) The presence of .15 part or more of albuminoid ammonia in a million ought certainly to condemn the water.

Judging the waters by these rules we must conclude:

(*a*) According to the first rule, all the waters except No. 10 should be condemned as drinking waters.

(*b*) By the second rule, all save 6, 7 and 10 would be excluded.

(*c*) By the third rule, all save 6, 8, 9 and 10 would be excluded.

(*d*) No. 3 is the only one which exceeds the limit given in the fourth rule.

In concluding from the sum of the evidence furnished by the chemical analyses we may, I think, decide that No. 10 is the only good water among the samples examined.

II. BACTERIOLOGICAL EXAMINATION.—Plate cultures were made, and the number of colonies counted, and pure cultures made from the plates.

A. The number of bacteria in a drop of each kind of water.

No. of sample	1	2	3	4	5	6	7	8	9	10
No. of colonies in a drop	50	46	120	50	26	18	18	36	20	8

B. Nature of the bacteria.

We have found the following germs: (1.) Liquefying bacillus, present in all the samples. It is a short, thick rod with rounded edges. It is not pathogenic.

(2.) Greenish—yellow bacillus, small fine rods, which liquefy gelatin rapidly—found in No. 4. It is non-pathogenic.

(3.) Micrococcus candicans—found in 1, 3 and 4. It does not liquefy gelatin, and is not pathogenic.

(4.) A gas forming bacillus; a small rod, very motile, liquefying gelatin and non-pathogenic.

(5.) A fluorescing bacillus; a short rod with rounded ends, does not liquefy gelatin and is non-pathogenic.

Besides these we have two germs, one from No. 2 and the other from No. 4, which we have not as yet been able to identify with any known germ. These we will study farther.

I can send you cultures of the germs isolated if you desire them. V. C. VAUGHAN, M. D.,

Director of the Michigan State Laboratory of Hygiene.

While it is true that these wells were selected from premises upon which typhoid fever had occurred, a year had elapsed after the occurrence of the sickness before the specimen was taken, and we would therefore expect to find in the water only those elements which are its usual constituents. Furthermore, it is of the utmost importance to bear in mind that these wells were not selected as being those most befouled, but were estimated to be a good average of all those examined. And I must add that, so far as I am able to conclude after extended observation and study of the matter, these wells are no worse than hundreds upon hundreds of other wells that are now in daily use in Omaha and highly esteemed for their excellence.

When objection is made to the water of a well, the reply will often be heard: "I will have the well cleaned out immediately," thinking that thus the evil can be remedied. This is a false notion that is very widely

received, and in order to call attention to this point, well No. 1 was chosen because it had been "thoroughly cleaned out" only three weeks prior to the taking of the sample; and No. 6 was cleaned only three days prior to taking the sample, and yet both of these wells are excluded by the chemical analysis, and No. 1 by each of the rules save the last.

It is by many erroneously supposed that if a well have sufficient depth all danger of contamination is eliminated. To illustrate the falsity of this position I selected No. 3, a well that is upwards of 130 feet deep. The analysis shows it to be the worst of all, being condemned by every rule.

The nearest neighbor to well No. 1, counted not less than twenty families who are supplied with water from this well, it being considered the best in the neighborhood, and yet its analysis condemns it by every rule save the fourth. The occupant of the house nearest well No. 8 stated that there is scarcely a time in the day when someone is not drawing water from it, but by two of the four rules it is condemned. The owner of No. 4 stated that a great many people use the water from it, but all the rules save the last condemn it. I have chosen these wells to show that it is an error to suppose that the use of an abundance of water from a well is a guarantee of its good quality.

In every instance, with the exception of Nos. 3 and 7, the wells examined were thought to contain the best of water. It is a fact that cannot be too strongly emphasized that the *taste and appearance of a water furnish no guide whatever as to its quality* for drinking purposes, even when sewage is present in large amount. The very elements which prove to the chemist that a water is dangerous, also contribute to that water a peculiar sparkling brilliancy and in many cases also an agreeable taste. This may be a hard blow to the fancied security of many, who will tell you that "Our well has splendid water; just as clear and sweet as can be." And yet we dare not stop even here.

The committee appointed by the American Public Health Association, on the pollution of water supplies, in its *report read at the annual meeting of that association at Milwaukee in November last, says: "We acknowledge that typhoid fever is propagated by an infected sewage in a well water when all organic trace of the sewage has disappeared through the instrumentality of the agencies referred to. [Chemical and biological changes.]

"There are two kinds of organic matter in the dangerous sewage—matter which, by the absence of life, is given up to decomposition and reduction to harmless inorganic forms; and matter which, by its vitality, is preserved from these influences; and we acknowledge that in the well water the former may be reduced, while the latter retains the full measure of its virulence."

Elsewhere, referring to its last annual report, the committee says: "Chemical analysis was shown to be, in most instances, inadequate to the detection of sewage, unless the sewage was present in unusual quantity, or the water unusually free from other organic matters; and the conclusion was reached that the inability of the chemical methods is of no practical importance, as the presence of sewage in the water supply can be determined by the sanitary inspector; and, further, that for protective purposes the knowledge that sewage enters the water is all that seems to be required, because where there is sewage there is danger of typhoid infection. Your committee desires to give special emphasis to the last stated clause, because it believes that the endemicity of typhoid fever in our cities is in great part due to the sewage in water supply."

Upon this question, Dr. Charles Smart, Major and Surgeon U. S. Army, makes the following *statement: "Usually in such wells (those contaminated by typhoid excreta) the sewage inflow is so great that the chemical results show an undesirable contamination; but in many instances the inflow is so small, or the purifying influence of the percolation through the soil is so great, that the infected water may give a fairly good showing on its analytical record. In other words, the quantity of infected sewage necessary to the spread of typhoid by a well water is so small as to

*Reprint for the Michigan State Board of Health.

*Annals of Hygiene, March, 1887.

evade detection by chemical methods; or the influence of a filtration, which effects the destruction of ordinary organic matter, leaves the specific poison unaffected and in full potency. So well are these facts recognized and acknowledged, that the health officers of many cities, having a trustworthy general supply, have not hesitated to close up the wells within their jurisdiction."

Prof. Chas. F. Chandler, of Columbia College, *says: "As a rule there is but little faith to be placed in analyses of well water if there is reason to suspect that the water is contaminated. I myself never feel like assuring a man that, because I find his water in a fair condition, he is safe from typhoid; it may be that at the time his water may be good, but the next week it may be bad. So much depends upon the state of the soil, the level of the cesspool, the season of the year, and so forth, that it is always rather against my conscience when I tell a man that his well is safe."

It will be worth while in this connection to give attention to some of the circumstances under which it is possible for wells to become contaminated.

In 1880 the National Board of Health inaugurated an elaborate series of experiments to determine the filtering power of various kinds of soils. Owing to the action of Congress they were discontinued in the summer of 1882, though far from completion. Nevertheless, valuable work was done. The following is from the report† of this Board. "From these results it appears very clearly that sand interposes absolutely no barrier between wells and the bacterial infection from cesspools, cemeteries, etc., lying even at great distances in the lower wet stratum. * * * At this point in our work it seems as though the filtering capacity were wholly dependant on the size and intricacy of the interstitial cavities; and that in the dry-air filters there is a critical limiting point, beyond which there is no filtering. And the same remarks seem to be true in different degrees with regard to the filtration of liquids. Here far greater fineness and compactness of grain and intricacy of passage are needed than are requisite for air filtration. While sand of 20° is an excellent air filter, sand of 100° in long columns is worthless for water, and the critical limiting point below which soils begin to exercise any filtering action probably verges on the size of grain of an impalpable powder."

Farther on this *report states as follows: "It would appear that the first inference from these experiments is that no substance sufficiently porous to allow of the passage of water can eliminate spores or bacteria from that water, even when moving upward by capillary attraction. There is no current so gentle that it can not buoy these infinitesimal bodies."

After a discussion on the subject of filtration which time does not allow me to reproduce, the committee of the American Public Health Association on Pollution of Water Supplies in its report in November last, uses these words:† "Since natural filtration is powerless against the infection of typhoid it is evident that artificial methods can give no guarantee of protection."

The Illinois State Board of Health says:‡ "The contaminating distance varies according to the nature of the soil and the depth of the well; in a loose, porous soil a well 30 to 40 feet deep will be dangerons if within 100 feet of typhoid premises."

According to experiments made by Prof. Victor C. Vaughan,§ "The excretion from one adult person's kidneys would be sufficient to poison one cubic foot of soil for that width if you had any water passing through it. Now with these facts we can easily estimate the time that any ordinary family with privy vaults would take to furnish enough effete matter to thoroughly permeate all the soil for a distance around it. The time would not be very long to render thoroughly impure every cubic foot of soil in the yard."

The same investigator examined samples of soil in the neighborhood of a privy vault issolated from other sources of contamination. The samples were taken from a point

*Women, Plumbers and Doctors, p. 78.
†Annual Report of the National Board of Health, 1882, p. 582.

*Loco Cit., p. 591. †Loco Cit.
‡Preventable Disease Circular, No. 4.
§Supplement to the Annual Report of the Michigan State Board of Health for 1886.

three feet below the surface, and in his own words:* "Without going into details, suffice it to say, that the contamination of the soil from that single privy, built upon nearly level ground, could be detected 50 feet from the vault, plainly."

Prof. Chandler, of New York, in his laconic way, says:* "You may take it as a rule that unless your cess-pool is as tight as a bottle the sewage will find its way to your own or your neighbor's well."

Prof. James H. Shepard, now chemist to the Dakota Agricultural College and Experiment Station, writing at Ypsilanti, Mich., †remarks: "I venture to say that not one person in fifty knows at what distance he lowers the level of the ground water when he lowers the water in his well by excessive pumping. It has been demonstrated that in soils somewhat similar to ours the level of the ground water is lowered for a distance of 200 feet in all directions from the well, while under the most favorable conditions the circle of influence may have an influence of over 2,000 feet. (Nichols Water Supply, pp. 109–114.) Now, for the sake of illustration, let any owner of a well in this town take a line 200 feet long, and with his own well as a centre, let him strike a circle, then let him count the privy vaults, old and new, cesspools, old and new, and all other sources of pollution within the circle; then he may know, approximately, upon how many reservoirs of death he is drawing when he works the handle of his pump."

The soil on which Omaha is built must be even more easily penetrated than that referred to by Prof. Shepard, and the diameter of the circle he describes consequently greater.

The soil of Omaha is a rather rare geological formation known as Loess. Of it Prof. Samuel Aughey, formerly State Geologist of Nebraska, ‡says: "Its drainage, which is the best possible, is owing to the remarkably finely comminuted silica of which the bulk of the deposit consists. Where the ground is cultivated, the most copious rains percolate through the soil, which in its lowest depths retains it like a huge sponge. When droughts come, the moisture comes up from below by capillary attraction." However, there is no scientific knowledge necessary to realize the remarkable facility with which water passes into the ground, as we see it all around us.

In a paper published in the *New York Medical Record* of October 29, 1887, I called attention to the great advantage afforded by a soil, possessing such rare qualities of drainage, in reducing the rate of sickness and mortality from consumption. In the present study, on the contrary, the opposite position must be taken. This property of soil, when rightly guarded and utilized, is a boon that few localities enjoy and no art of man can supply. But let disease breeding centers in the form of privy vaults and cesspools be scattered thickly through it and this perfection of drainage, which ought to exert so salutary an influence upon the health of the community, becomes, by so much, an additional danger wherever wells are used. The distance that filth may travel to a well and the certainty of its reaching it is, by so much, increased.

From the foregoing testimony I have carefully excluded all save that which is admitted to be authoritative upon the points at issue, and the conclusion is to my mind unavoidable: (1.) That the great majority of the wells in the city of Omaha have sewage draining into them; (2.) That no possible filtration, which this sewage may receive by passing through the soil from its source to the well, can remove from it its dangerous and perhaps fatal qualities.

The question is naturally suggested: "What was the reason of the unusual outbreak of typhoid in 1887?"

The mortality records give the number of deaths from typhoid fever in Omaha year by year, as follows: In 1880, 20; in 1881, 33; in 1882, 32; in 1883, 17; in 1884, 17; in 1885, 17; in 1886, 18; in 1887, 103, and in 1888, 56.

In 1869 Prof. Pettenkofer clearly established the fact of a rythmical variation in Munich of the death rate from typhoid fever to correspond to the height of the ground-water, *i. e.*, high ground-water with low death-rate and low ground-water with high death-rate.

*Loco Cit.

†Supplement to the Annual Report of the Michigan State Board of Health for the year 1885.

‡Sketches of the Physical Geography and Geology of Nebraska, 1880.

From a vast accumulation of evidence Pettenkofer showed that the mathematical probability was as 36,000 to 1 that there existed a causal relation between the low ground-water and the increased typhoid.

In October, 1884, Dr. Henry B. Baker, Secretary of the Michigan State Board of Health, read a paper* before the American Public Health Association at its meeting in St. Louis. In this admirable essay Dr. Baker clearly demonstrated that in Michigan the same relation exists of the ground water to typhoid as was pointed out by Prof. Pettenkofer. Dr. Baker, however, accounts for this causal relation upon a different theory from that proposed by Pettenkofer, viz: That it is the low water in wells to which it is attributable. His exceedingly interesting argument I have not space to reproduce. To me, his conclusion appears unavoidable, that the increased typhoid rate which accompanies a fall in the ground-water, is brought about directly through the accompanying fall of the water in the wells, chiefly by producing greater concentration of the sewage therein. It will be seen at once that this theory is not out of harmony with the supposition that the wells were the main cause of the typhoid fever in Omaha in 1887. But if it be true, as I allege, that this outbreak was caused by the wells, and if it is also true that Dr. Baker's theory is correct, we would expect to find a marked lowering of the water in the wells during that year. Now, there having been no measurements taken with reference to this point, so far as I am aware, I have consulted the records of the U. S. Signal Service for light upon this matter. Through the courteous assistance of the Observer at the Omaha station. Mr. L. A. Welsh, I have ascertained the following facts:

1. The normal (average) annual rainfall at this station, computed from the observations of sixteen years, is 35.73 inches.

2. During the last nine months of 1886 there was a deficiency of 13.03 inches, equal to 36½ per cent. of the normal for the whole year.

3. During 1887 there was a deficiency of 15.83 inches, equal to 44 per. cent of the annual normal, or almost one-half. In other words, during this year and three-quarters of the preceding one, the amount of precipitation fell short of the usual precipitation for that period by about thirty inches. Thus, though not a well was measured, there can be no doubt that so prolonged and severe a drought must have very decidedly lowered the water in the wells; and the delectable sewage mixture must have been proportionately concentrated, as explained by Baker.

In conclusion, it must be admitted that typhoid fever is absolutely controllable and preventable, and that, in the light of the present day, its occurrence, unless it be in isolated instances, is a reproach to the community which suffers by it.

If the excuse of ignorance has heretofore carried any merit, I trust that I have been able to put that aside.

And yet, however much we may proclaim the danger in such insanitary conditions there will be many who believe that by their own unaided intuition, they are so wise that all the research and experience of a quarter of a century, conducted by the most earnest and scientific workers, can teach them nothing. Such persons will go on drinking poison until they are stricken down by the ghastly fever, and then they will blaspheme a good and merciful God by ascribing to "a mysterious Providence," that which is a direct result of their own criminal ignorance. A popular doctrine of such individuals is briefly stated and answered by Prof. J. H. Shepard as follows:* "That these Boards of Health and Water Analyses, etc., etc., are simply new-fangled crazes, which are untrustworthy and soon doomed to decadence."

With us, alas, they are new-fangled, but for any one to denominate them as crazes is simply to expose his ignorance. Go to Germany, England, or France and ask if these are crazes. We are simply ignorant of their value, and may God shield us from knowing their value by passing through the horrors of the plague. The water supply of such cities as London is daily subjected to analyses to determine its purity, while the mandates of the health officers in plague-stricken Europe are more absolute than those of the king.

If I might venture to make a suggestion

*Typhoid Fever and Low Water in Wells.

*Loco Cit.

I would respectfully urge upon our Health Board the prompt adoption of energetic measures for the remedy of this evil. Many towns having such a difficulty as this to overcome have been brought face to face with the problem of securing an adequate and pure public water supply, which could only be done at enormous expense. But this we are spared, for such a supply is already flowing through the mains in our streets.

The only obstacle, then, to the removal of this menace, which daily threatens with typhoid fever every man, woman and child in Omaha, who has not had the disease, is the expense attendant upon filling up wells and introducing the public supply.

In 1887 there were not less than 1,000 cases of typhoid in Omaha, and over 80 per cent. of these were persons in the self-supporting period of life. If these were disabled from work an average of sixty days each, and were each capable of earning one dollar per day (both low estimates), the actual loss of time, without regard to the unprofitable labor of nursing, expense of physician, medicines, etc., amounted to $57,600. Saving money by drinking sewage is a form of economy which no community can afford. Let information upon this subject be disseminated among the people. Provide for the inspection and chemical examination of their wells and many of the people will voluntarily close them. But to enjoy life is a privilege guaranteed to every citizen, by the constitution of the United States, and wells which are a menace to the lives of the community should be closed by the power of law when this power must be invoked to accomplish that end. So shall valuable lives be saved to the city and the world, and a reproach be removed from the fair name of Omaha.